

WHAT IS CLAIMED IS:

- 1                   1.     A method for depositing a film on a substrate in a process  
2 chamber, the method comprising:  
3                   providing a first gaseous mixture to the process chamber;  
4                   generating a plasma from the first gaseous mixture with a plasma source  
5 disposed within the process chamber to deposit a first portion of the film on the  
6 substrate;  
7                   thereafter, flowing an etchant gas into the process chamber without  
8 terminating the plasma to etch part of the first portion of the film; and  
9                   thereafter, providing a second gaseous mixture to the process chamber  
10 without terminating the plasma to deposit a second portion of the film on the substrate.
- 1                   2.     The method recited in claim 1 further comprising applying an  
2 electrical bias to the substrate while flowing the etchant gas.
- 1                   3.     The method recited in claim 2 wherein the bias has a power  
2 density approximately between  $0.9 \text{ W/cm}^2$  and  $3.2 \text{ W/cm}^2$ .
- 1                   4.     The method recited in claim 1 wherein the second gaseous  
2 mixture is substantially the same as the first gaseous mixture.
- 1                   5.     The method recited in claim 1 wherein the first and second  
2 gaseous mixtures each include a silicon-containing gas and an oxygen-containing gas,  
3 and wherein the etchant gas includes a fluorine-containing gas.
- 1                   6.     A method for depositing a film on a substrate in a process  
2 chamber, the method comprising:  
3                   providing a first gaseous mixture to the process chamber, the first  
4 gaseous mixture comprising a first deposition gas and an etchant gas; and  
5                   generating a plasma from the first gaseous mixture with a plasma  
6 coupling structure to simultaneously deposit a first portion of the film on the substrate  
7 and etch the film, wherein the plasma includes poloidal ion flow along field lines  
8 substantially parallel to a surface interior to the process chamber and disposed to  
9 separate the plasma from the plasma coupling structure.

1                   7.     The method recited in claim 6 further comprising providing a  
2 second gaseous mixture to the process chamber without terminating the plasma, the  
3 second gaseous mixture comprising a second deposition gas, to deposit a second  
4 portion of the film.

1                   8.     The method recited in claim 6 further comprising applying an  
2 electrical bias to the substrate.

1                   9.     The method recited in claim 8 wherein the bias has a power  
2 density approximately between 0.9 W/cm<sup>2</sup> and 3.2 W/cm<sup>2</sup>.

1                   10.    The method recited in claim 8 wherein the bias has a power  
2 density approximately between 0.9 W/cm<sup>2</sup> and 1.6 W/cm<sup>2</sup>.

1                   11.    The method recited in claim 6 wherein the plasma is a high-  
2 density plasma.

1                   12.    The method recited in claim 6 wherein the second deposition gas  
2 is substantially the same as the first deposition gas.

1                   13.    The method recited in claim 6 wherein the first deposition gas  
2 includes a silicon-containing gas and an oxygen-containing gas, and wherein the  
3 etchant gas includes a fluorine-containing gas.

1                   14.    A computer-readable storage medium having a computer-  
2 readable program embodied therein for directing operation of a substrate processing  
3 system including a process chamber; a plasma coupling structure; a substrate holder;  
4 and a gas delivery system configured to introduce gases into the process chamber, the  
5 computer-readable program including instructions for operating the substrate  
6 processing system to form a film on a substrate disposed in the process chamber in  
7 accordance with the following:

8                   providing a first gaseous mixture to the process chamber, the first  
9 gaseous mixture comprising a first deposition gas and an etching gas;  
10                  generating a plasma from the first gaseous mixture with the plasma  
11 coupling structure to simultaneously deposit a first portion of the film on the substrate  
12 and etch the film, wherein the plasma includes poloidal ion flow along field lines

13 substantially parallel to a surface interior to the process chamber and disposed to  
14 separate the plasma from the plasma coupling structure.

1 15. The computer-readable storage medium recited in claim 14, the  
2 computer-readable program further including instructions for applying an electrical bias  
3 to the substrate.

1 16. The computer-readable storage medium recited in claim 14, the  
2 computer-readable program further including instructions for providing a second  
3 gaseous mixture to the process chamber without terminating the plasma, the second  
4 gaseous mixture comprising a second deposition gas, to deposit a second portion of the  
5 film.

1 17. A computer-readable storage medium having a computer-  
2 readable program embodied therein for directing operation of a substrate processing  
3 system including a process chamber; a plasma generation system having a plasma  
4 source disposed within the process chamber; a substrate holder; and a gas delivery  
5 system configured to introduce gases into the process chamber, the computer-readable  
6 program including instructions for operating the substrate processing system to form a  
7 film on a substrate disposed in the process chamber in accordance with the following:

8 providing a first gaseous mixture to the process chamber;  
9 generating a plasma from the first gaseous mixture with the plasma  
10 source;

11 thereafter, flowing an etchant gas into the process chamber without  
12 terminating the plasma to etch part of the first portion of the film; and

13 thereafter, providing a second gaseous mixture to the process chamber  
14 without terminating the plasma to deposit a second portion of the film on the substrate.

1 18. The computer-readable storage medium recited in claim 17, the  
2 computer-readable program further including instructions for applying an electrical bias  
3 to the substrate while flowing the etchant gas.

1 19. A substrate processing system comprising:  
2 a housing defining a process chamber;  
3 a plasma generating system operatively coupled to the process chamber  
4 and including a plasma coupling structure disposed within the process chamber;

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5 a substrate holder configured to hold a substrate during substrate  
6 processing;  
7 a gas-delivery system configured to introduce gases into the process  
8 chamber, including sources for a silicon-containing gas, a fluorine-containing gas, and  
9 an oxygen-containing gas;  
10 a pressure-control system for maintaining a selected pressure within the  
11 process chamber;  
12 a controller for controlling the plasma generating system, the gas-  
13 delivery system, and the pressure-control system; and  
14 a memory coupled to the controller, the memory comprising a computer-  
15 readable medium having a computer-readable program embodied therein for directing  
16 operation of the substrate processing system, the computer-readable program including  
17 instructions to control the gas-delivery system to provide a first  
18 gaseous mixture to the process chamber, the first gaseous mixture comprising a first  
19 deposition gas that includes the silicon-containing gas and the oxygen-containing gas  
20 and an etchant gas that includes the fluorine-containing gas; and  
21 instructions to control the plasma generating system to generate a  
22 plasma from the first gaseous mixture to simultaneously deposit a first portion of the  
23 film on the substrate and etch the film, wherein the plasma includes poloidal ion flow  
24 along field lines substantially parallel to a surface interior to the process chamber and  
25 disposed to separate the plasma from the plasma coupling structure.

1 20. The substrate processing system recited in claim 19, the  
2 computer-readable program further including instructions for applying an electrical bias  
3 to the substrate.

1 21. The substrate processing system recited in claim 19, the  
2 computer-readable program further including instructions for providing a second  
3 gaseous mixture to the process chamber without terminating the plasma, the second  
4 gaseous mixture comprising a second deposition gas, to deposit a second portion of the  
5 film.

1 22. A substrate processing system comprising:  
2 a housing defining a process chamber;

3 a plasma generating system operatively coupled to the process chamber,  
4 the plasma generating system including a plasma source disposed within the process  
5 chamber;  
6 a substrate holder configured to hold a substrate during substrate  
7 processing;  
8 a gas-delivery system configured to introduce gases into the process  
9 chamber, including sources for a silicon-containing gas, a fluorine-containing gas, and  
10 an oxygen-containing gas;  
11 a pressure-control system for maintaining a selected pressure within the  
12 process chamber;  
13 a controller for controlling the plasma generating system, the gas-  
14 delivery system, and the pressure-control system; and  
15 a memory coupled to the controller, the memory comprising a computer-  
16 readable medium having a computer-readable program embodied therein for directing  
17 operation of the substrate processing system, the computer-readable program including  
18 instructions to control the gas-delivery system to provide a first  
19 gaseous mixture to the process chamber;  
20 instructions to control the plasma generating system to generate a  
21 plasma from the first gaseous mixture with the plasma source to deposit a first portion  
22 of the film on the substrate;  
23 instructions to control the gas-delivery system to flow, thereafter,  
24 an etchant gas into the process chamber without terminating the plasma to etch part of  
25 the first portion of the film; and  
26 instructions to control the gas-delivery system to provide,  
27 thereafter, a second gaseous mixture to the process chamber without terminating the  
28 plasma to deposit a second portion of the film on the substrate.

1 23. The substrate processing system recited in claim 22, the  
2 computer-readable program further including instructions for applying an electrical bias  
3 to the substrate while flowing the etchant gas.